

Abrams Angiography

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Catheters and Injectors

STANLEY BAUM

Catheter abdominal aortography was first performed in man by Ickikawa in 1938 [1]. A ureteral catheter was passed retrograde through a surgically exposed femoral artery into the abdominal aorta. Contrast material was injected through the catheter, and the renal arteries were visualized. In 1951 Radner [2] described his technique of catheter vertebral arteriography. A ureteral catheter was introduced into the surgically exposed radial artery and passed retrograde into the vertebral artery. It was the first time that selective catheter arteriography had been performed. Then, as now, safe diagnostic arteriography was largely dependent on proper catheter position. In the early days of angiography rubber ureteral catheters were the only ones available. Advances in plastic chemistry have been responsible for the development of materials that lose both shape and form when heated and regain them when cooled. The properties of thermoplastic tubing are modified by the manufacturing process, and different types are known commercially by various names: polytetrafluoroethylene as Teflon, polyamide as nylon (both E. I. duPont de Nemours & Co., Inc.), etc.

Angiographers have the option of using pre-shaped molded catheters or less expensive catheters that are supplied in long rolls, custom-made by the radiologist for a particular case and discarded after one use.

Custom-made Catheters

It is almost always desirable to use radiopaque catheters in order to facilitate their manipulation and guidance. Incorporation of enough radiopaque material in the thermoplastic to make the catheter radiopaque frequently causes changes in the catheter characteristics. For example, radiopaque Teflon becomes much softer and less elastic than nonopaque Teflon. Polyethylene seems to change the least when it is made radiopaque. For this reason, one of the earliest radiopaque catheter materials available was the Kifa tubing (Kifa, Solna, Sweden), in which lead oxide was incorporated into the polyethylene. Because polyethylene does not soften significantly at body temperature, it has remained a favorite material for selective catheterization. Radiopaque polyethylene catheters are at present available from many manufacturers.

These catheters are supplied in rolls of 10 to 20 feet and are color-coded according to their

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improving resolution, particularly where there is a considerable amount of overlying dense bony structure that obscures some of the vascular details. Good subtraction requires good filming and photographic techniques. Moreover, a critical requirement is that there be absolutely no patient movement. Patient movement can result in the creation of suspect lesions that are really artifactual as well as the loss of important information that actually was present on the nonsubtracted film.

The use of a photofluorographic system (70-, 90-, 100-, and 105-mm cameras) for carotid angiography has been under investigation for many years. In the past, the quality of films was often poor, and hence these units were not widely used for cerebral angiography. However, the newer units provide much higher resolution and also offer substantial convenience. Finally, the cost of conventional x-ray film has increased to such a degree that cameras will probably occupy an important place in carotid angiography in the future, if for no other reason than economic. Another advantage of photofluorographic systems is, of course, the reduction in radiation exposure for the patient.

The necessity for good basic radiographic technique must always be emphasized. It is absolutely essential that tight coning be used, that good film-screen contact be present in the film changers, that the optimum film-screen combination be found for maximum resolution and minimum radiation dose, and finally, that good-quality film processing be carried out with continuous quality control of the film processing.

Radiographic Equipment

An angiographic table with movable tabletop and accompanying headboard that keeps the patient's head independent of the film changers, a fluoroscopic unit for both anteroposterior and lateral fluoroscopy, two x-ray tubes, one with a focal spot no larger than 0.3 mm and one with a focal spot of 0.1 mm, a 1,000-mA or larger three-phase generator, two rapid film changers, and a mechanical contrast injector such as a Viamonte-Hobbs or Medrad are desirable for good cerebral angiography. In the future, as mentioned before, photofluorographic systems may replace, at least in part, the conventional rapid film changers.

Patient Monitoring

The patient should be continuously monitored by electrocardiography and frequent blood pressure

determinations. Also, continuous evaluation of the patient's sensorium and basic neurologic function (motor, visual fields, sensory, speech) should be carried out. For this reason, we prefer that the patient not be under general anesthesia unless absolutely necessary.

POSTANGIOGRAPHIC CARE OF PATIENT

Close attention to detail is necessary in the post-angiographic care of the patient in order to prevent or minimize possible complications of the procedure. Compression of the introduction puncture site after removal of the catheter and/or needle should be painstakingly carried out. The goal of the compression maneuver is to increase the tissue pressure in the immediate vicinity of the puncture so that the pressure outside the puncture site is equal to or slightly greater than the blood pressure inside the vessel. This should prevent the flow of blood through the puncture site and permit adequate hemostasis to seal the site. At the same time, one does not wish to increase the outside pressure to such a degree that the carotid artery or femoral artery is completely occluded during the compression period. In all cases, a minimum of 10 minutes' compression monitored with an overhead clock is recommended. In patients with hypertension or in patient in whom there is some deficiency in blood clotting, the time may have to be extended to 15 or even 20 minutes. Usually, axillary artery puncture sites require more compression than other locations; we recommend 15 or 20 minutes. When the patient is returned to his room after the procedure, often an ice pack placed on the puncture site will give additional relief and minimize pain and swelling.

The patient's vital signs must be monitored at frequent intervals for at least the first 12 hours following the procedure. We usually prefer that for the first hour following the procedure the vital signs be checked every 15 minutes; for the next 2 hours, every 30 minutes; and after that, at hourly intervals. At the same time, the catheter or needle puncture site should be inspected for possible hematoma formation, and the relevant leg in the case of a femoral puncture should also be monitored for distal pulse and skin temperature and for any signs suggesting possible occlusion of the femoral artery or distal branches. In patients with an axillary artery study, of course, one would want to monitor the pulsations and temperatures of the upper extremity involved. In

general, there is no need to be concerned about the distal arm circulation as a result of a retrograde brachial study, as long as this study has been carried out only with a puncture needle or a plastic puncture-needle sleeve. The patient's physical activity should be restricted for the first 24 hours following the angiographic study, particularly activity in the extremity used for catheter introduction.

Just as it is important that the patient be adequately hydrated before the initiation of the angiographic procedure, it is also important that adequate hydration be maintained following the procedure. This safeguard is especially relevant in view of the diuretic effect of the contrast agents used for angiography.

Finally, it is recommended that the neuro-radiologist and/or his special procedure nurse check the patient 24 hours after the carotid angiogram for return of normal pulsations, normal extremity temperatures, possible hematoma formation, etc. The patient's psychologic reaction to the study should be evaluated. If the patient found the examination a terrifying or very uncomfortable experience, one should determine the specific reasons for the patient's reaction. Where possible, steps should be taken to modify the angiographic procedure in order to make it less unpleasant for patients undergoing future studies.

Other Cerebral Angiographic Procedures

VERTEBRAL ANGIOGRAPHY

Most vertebral angiography today is performed with the selective catheterization technique similar to the selective technique for carotid angiography. The catheter is directed from the aortic arch into the desired vertebral artery and is usually passed only a few centimeters up the artery. If the patient has a very small vertebral artery, the catheter should not be introduced and the study should be carried out via the opposite artery, which will ordinarily be substantially larger. In the case of severe atherosclerotic disease involving the proximal vertebral arteries, it may be necessary to inject contrast with the tip of the catheter placed either in the origin of the vertebral artery or actually in the subclavian artery immediately adjacent to the origin of the vertebral artery. In the latter case, a larger contrast bolus may be required, usually about 20 cc of Conray-60, Hypaque-60, or Renografin-60.

Normally, when the catheter has been positioned in the lumen of the vertebral artery, a bolus of 6 cc of contrast agent is adequate for good visualization of the vertebral-basilar system and will also produce a momentary reflux of contrast into the opposite vertebral artery retrograde fashion from the origin of the basilar artery. It is extremely important that a test dose of contrast be injected into the artery under fluoroscopic control as soon as the catheter is positioned in the vertebral artery in order to rule out the possibility of the catheter's actually obstructing blood flow in the artery. If fluoroscopic inspection demonstrates slow flow of contrast or no flow of contrast, the catheter should be immediately withdrawn into the subclavian artery.

Conventional projections required for vertebral angiography include an anteroposterior half-axial view with about 25 degrees angulation of the central x-ray beam toward the feet with respect to the canthomeatal line (see Fig. 10-2), a lateral view with the central beam centered about 2 cm posterior to the external auditory meatus (see Fig. 10-3), and sometimes an anteroposterior transfacial view centered in such a way that the central beam will pass through the midclivus at approximately 90 degrees angulation with respect to the plane of the clivus. Subtraction techniques are almost always necessary for evaluation of the transfacial anteroposterior views.

When satisfactory vertebral-basilar visualization cannot be obtained with the catheter technique, the retrograde brachial method may prove a satisfactory alternative. Direct percutaneous puncture of the vertebral artery is rarely used today.

AORTIC ARCH ANGIOGRAPHY

Occasionally, visualization of the origin of the brachiocephalic vessels is necessary, in which case injection of contrast into the aortic arch is required. If the patient is being studied for evaluation of a disease process of the brain, it is usually desirable to visualize the intracranial vascular tree in addition to the brachiocephalic vessels. In this situation, it is preferable that the usual techniques for carotid and vertebral angiography be carried out as described in previous sections. Then if visualization of the origin of the brachiocephalic vessels is needed, the 5 French catheter used for the selective carotid and/or vertebral studies can be removed and a 6.5 French catheter with side holes introduced into the aortic arch (catheter tip in ascending aorta). This would be the final